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SENSITIVITY OF IDEALIZED SQUALL LINE SIMULATIONS TO THE LEVEL OF COMPLEXITY USED IN TWO TWO-MOMENT BULK MICROPHYSICS SCHEMES

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ABSTRACT

Regional-scale weather forecasting models now operate using multi-moment bulk microphysics, predicting two or three moments of various liquid and ice hydrometeor distributions. Such complexity is difficult to duplicate in global climate models, mainly due to the large computational burden. Hence, an important question to address is: what level of complexity is required to simulate the essential processes relevant to climate studies, given their increasing interest in convective scales? To tackle this question, we investigate the sensitivity of idealized squall line simulations to the level of complexity used in the microphysics schemes. Factors examined include the number of predicted moments, the number and nature of predicted ice categories, and the formulations of the conversion processes. These investigations are conducted within the framework of two commonly used two-moment microphysics schemes (Morrison et al. 2005; Milbrandt and Yau 2006), and serves to also help understand which aspects are most responsible for variability between both schemes.

Cold-pool development was mainly influenced by the number of predicted moments of the graupel category in both schemes; subsequent to its melting, it dramatically changed the rain size distribution and hence evaporation characteristics. Surface precipitation seemed to be controlled to a large extent by how much water entered the snow (and to a lesser extend the graupel) category. The more water stored in these slowly sedimenting categories, the more delayed the precipitation fallout and the smaller the peak precipitation. This aspect was mainly controlled by the formulation of the snow-growth terms and also explained most of the variability between both microphysics schemes (given an identical setup in terms of size distribution assumptions). However, total precipitation accumulations after 4 hours of simulation seemed to be rather unaffected by any of the experiments.
The distribution of water among the ice categories tends to be very sensitive to the precise conversion or size distribution formulations. This research in general advocates the use of newer approaches of representing microphysics that predict the rimed fraction of a single precipitating ice category (*e.g.*, Morrison et al. 2008, Colle et al. 2010), which avoids the artificially abrupt separation between either totally rimed (quickly sedimenting) or unrimed (gently sedimenting) categories.